3.2 3440 Keypad Layout

The Series 3440 Gauge control panel consist of 22 keys (Figure 31): the 20 key control section and the ON/OFF keys. Keystrokes result in an immediate “beep” from the gauge. If the beep is not heard, the operation is not completed. Gauge and control panel operation are described throughout the manual.

SHIFT and SHIFT FUNCTION keys are color coded yellow for ease of identification. SHIFT must be pressed before pressing a function key. Functions are directly addressable from any other function except the calculator mode. Pressing SHIFT causes the display’s top line to change to <SHIFT FUNCTION>.

Note: If a function key is not pressed within 4 seconds, the gauge reacts as if no key was pressed. If there is no action after pressing a key, the gauge will return to READY after 2 minutes.

YES, NO and START/ENTER keys apply to all gauge modes. Pressing START/ENTER from most modes will abort the mode and begin a test.

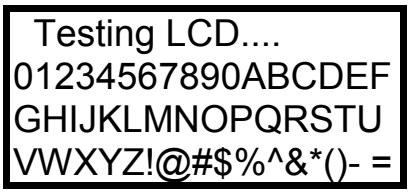
The calculator function keys are MS, MR, +, -, x, ÷, and =.

3.3 Turning The Gauge On

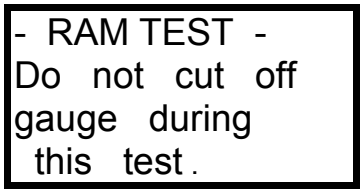
The gauge uses rechargeable Ni-Cad batteries as a power source. When first turned on, the display screen will fill with test characters before proceeding to the ram test and the self-test phase.

To turn the gauge on, press **ON**.

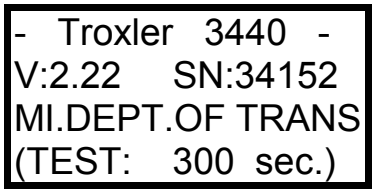
The display is the LCD test:



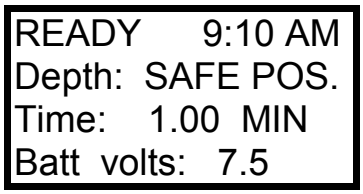
After 2 seconds, the display will change to:



The gauge will perform the ram test. After the ram test, the display will be:



The gauge will undergo a 300 second self-test. After the self-test, the display will be:



Alternating between the date and time, the READY display will be shown each time the gauge is ready to proceed to another function or there is no activity for more than 2 minutes.

Under certain conditions, the gauge will shut itself off after 5 hours of no activity.

3.4 Recharging The Batteries

The READY display shows the amount of voltage left in the battery packs and will be shown as “Batt volts: 7.5”. When the battery packs voltage drops below 7.0 volts the gauge will indicate **<Batteries low!>**. Never recharge the batteries unless the gauge indicates a **<Batteries low!>** condition. It takes a 16 hour charge to completely recharge the battery packs. A 30 minute recharge will allow the gauge to be used for another 8 to 10 hours. Don’t leave the charger hooked up to the gauge over a weekend.

3.5 Taking The Standard Counts

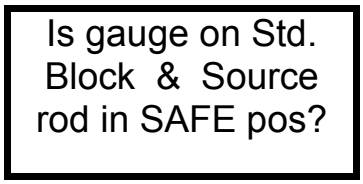
Note: The front of the gauge is closest to you when the 3440 is placed with the source rod to the left and the control panel to the right. The handle contains the trigger mechanism, used to position the source rod on the notched index rod. The source rod should always be in the SAFE position when the gauge is not in use.

The gauge should be turned ON before leaving for the project site. This allows the gauge to go through the self-test routines. The gauge should be ON for approximately 20 to 30 minutes before attempting to run the standard counts. From the Gauge Book, obtain the standard counts established when the gauge was calibrated and record in the lower right hand corner of Form 582B, (Figure 29) under Chart Standards. Place the standard block on a flat surface of sound earth **6 feet** (2 m) away from any large object (pickup, structure, etc.) or wet area (mud puddle, stream, etc.). Making sure the top of the standard block and the bottom of the gauge are clean, place the gauge correctly on the standard block. The gauge must be positioned between the raised edges of the block and with the Scaler end of the gauge up tight against the metal butt plate on the block. Remove the lock from the trigger and make certain the handle is indexed in the SAFE position.

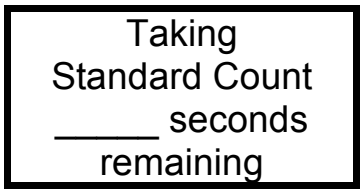
To begin taking a standard count, press **STANDARD** for the display:

```
- Standard Count -
  DS = _____
  MS = _____
Take new count?
```

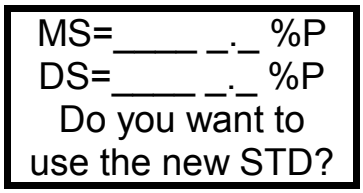
Press **YES** for the display:



Make sure the gauge is placed on the reference block correctly. Place the source rod in the SAFE position and press **YES** to begin taking the 4 minute standard count:



After count completion, the display is:



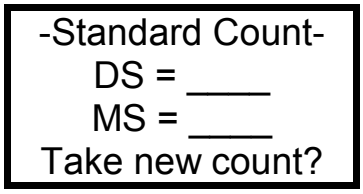
The standard count (operating standard) should not deviate from the chart standards obtained from the Gauge Book by more than 1 percent for density or 2 percent for moisture. If the standard counts are within acceptable limits, press **YES** to accept. Record the standard counts in the lower right corner of Form 582B, (Figure 29) under Operating Standards. If either value is out of range, press **NO** and take another standard count. Before repeating the standard count, make sure the gauge base and reference block are clean and the gauge is positioned correctly on the reference block. If either standard is still out of tolerance, call the Area Density Specialist or Lansing staff immediately to make arrangements to have the gauge serviced or replaced. The gauge should be serviced or replaced within 24 hours.

To determine if the gauge can continue to be used until serviced or replaced, do the following:

Repeat the standard count procedure 5 times, saving each result when prompted. On completion of the fifth standard count, check the display to determine status. If the standards for the fifth count are within tolerance, ± 2 percent for moisture, a **P** will show in the upper right corner of the display. If passing results are indicated, you may continue to use the gauge for 24 hours. If either standard fails, an **F** will show on the display and the gauge should be taken out of service immediately.

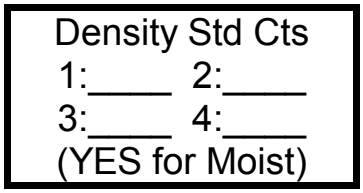
3.6 Viewing The Last Four Standard Counts

To "View" the last 4 standard counts, press **STANDARD**, for the display:

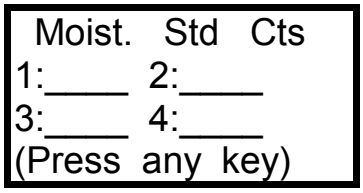


Press **NO** for the display:

Press **YES** for the display:



To view the “Moisture Standard Counts,” press **YES**. The display will be:

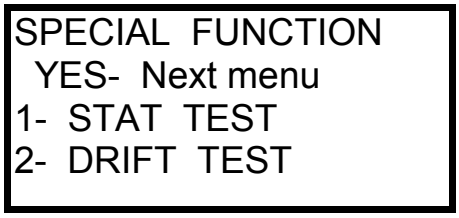


The “View Standard Count” function may be exited by pressing any key.

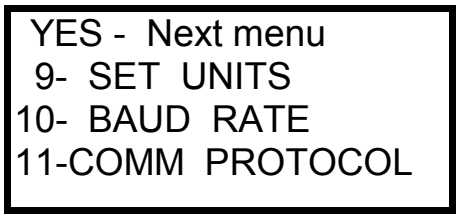
3.7 Setting Measurement Units

Prior to taking measurements, the user should determine the “Unit of Measurement” that is required for screen displays and/or printouts. The available selection is either “PCF” or “Metric”.

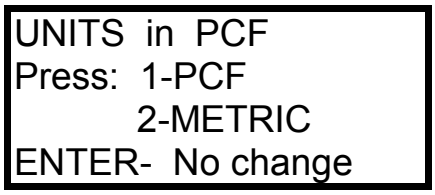
To execute the “SET UNITS” function, press **SHIFT** and **SPECIAL** for:



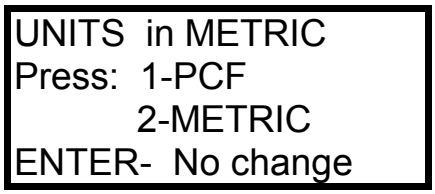
Press **YES** 3 times for the display:



Press **9** for the display:



or, the display will be:

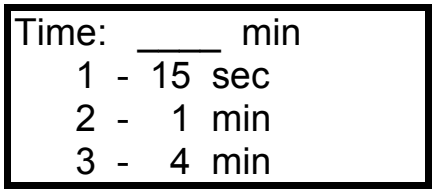


Press either **1** or **2** for the required units.

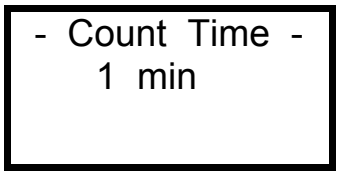
3.8 Count Time Selection

The 3440 gauge provides 3 different count times to be used for taking readings. **When running In-Place Moisture/Density Tests always use the <u>1 minute</u> time cycle**. Never use the 15 second time cycle.

Press **TIME** for the display:



Press **2** to select 1 minute count:

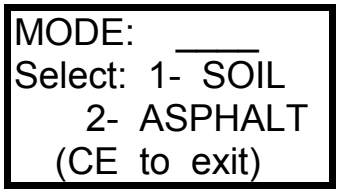


After a short delay, the display will return to READY.

3.9 Mode Selection

The Mode function provides for the selection of SOIL or ASPHALT mode. Under ASPHALT mode, the sub-mode selection of "% Marshall" is always used.

To select the Mode Functions, press **SHIFT** and **MODE** for:



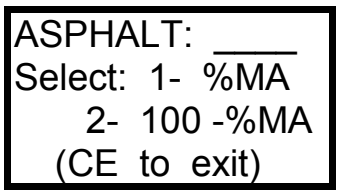
A. Soils Mode Selection

From the Mode Selection display, press **1** to select SOIL mode. The display will be:

After a short delay, the display will return to READY.

B. Asphalt Mode Selection

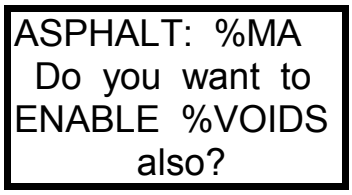
From the Mode Selection display, press **2** to select ASPHALT mode. The display will be:



Asphalt Mode - % Marshall

% Marshall = (WD/Marshall) x 100

Select "% Marshall" by pressing **1** from the Asphalt Mode Selection display. The display will be:



Always press **NO** when it asks if you want to enable "% Voids".

3.10 Density/Moisture Measurement

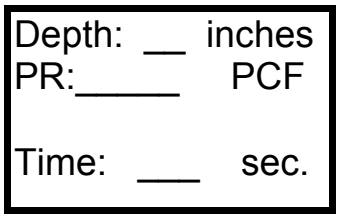
A. Soils Mode

Enable the SOIL mode prior to taking a measurement. Check units of measurement, count time, and Maximum Density.

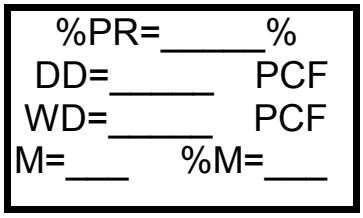
After the test site is selected, the surface of the soil to be tested must be prepared. Surface condition is very important and can affect gauge performance and the accuracy of test results. Using the template as a scraper, smooth the test surface. Place the template on the surface and move it back and forth in all directions to smooth the test site. Remove the template and fill small depressions or voids present with sand or fine material available near the test site.

Place the template on the surface again and press down firmly to level. Using your foot to hold the template firmly, take the drill rod and drive it to the desired test depth. When running tests on soils, always use one of the "Direct Transmission" test positions (2, 4, 6, and 8 inches). Still holding the template firmly with your foot, twist the drill rod and remove it by pulling straight up. Do not loosen the drill rod by tapping from side to side with the hammer. Use the drill rod to scribe along 3 sides of the template. After removing the drill rod and template, place the gauge on the test site and insert the source rod into the driven hole to the depth (2, 4, 6, or 8 inches) at which the test is to be taken. Facing the Scaler end of the gauge, pull the gauge toward you to seat the source rod against the side of the driven hole.

To start the measurement, press **START/ENTER** for the display:



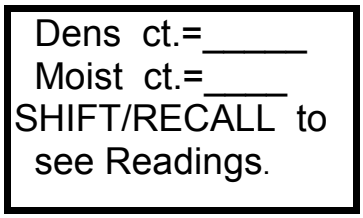
After the gauge completes its count time, the display will be:



Record DD, WD, M, and %M in the correct columns on Form 582B.

Note: Do not record %PR until the correct Maximum Density has been enabled.

To obtain the density and moisture test counts press **SHIFT** and **COUNTS** for the display:



Record the counts in columns 3 and 6 on Form 582B.

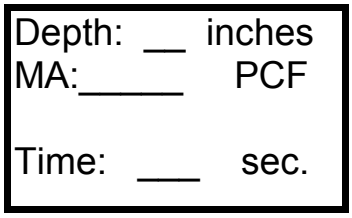
B. Asphalt Mode

Enable the ASPHALT mode prior to taking a test on Hot Mix Asphalt (bituminous) materials. Check units of measurement, count time, and Maximum Density.

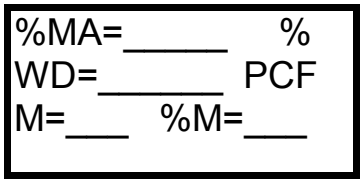
Select the test site and make sure the site is flat before setting the gauge down. Place the source rod in the BACKSCATTER position.

Note: When testing base course, leveling course, or Detail 8 Joints use a "Direct Transmission" position test when the layer is greater than 2 inches thick.

Start a measurement by pressing **START/ENTER**. The display will be:



After the gauge completes its count time, the display will be:



Record WD and %M in the correct columns of Form 582B.

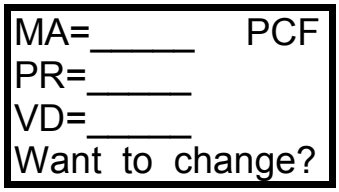
Note: Do not record %MA until the correct Maximum Density has been enabled.

To obtain the density and moisture test counts press **SHIFT** and **COUNTS**. Record the counts in columns 3 and 6 on Form 582B.

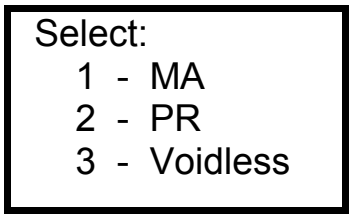
3.11 Proctor (Cone)/Marshall/Voidless Function

The 3440 gauge provides for up to four different Proctor (Cone) values and four different Marshall values to be stored for later use.

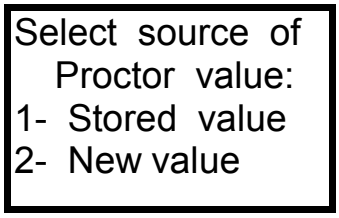
To select or change a Proctor (Cone) or Marshall Density value press the **PROCTOR /MARSHALL** key for the display:



If a value is to be enabled or a new value added or changed, press **YES**. The display is:

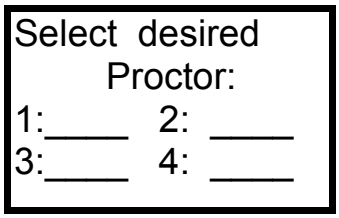


Marshall and Proctor (Cone) functions are identical as far as operation is concerned. Therefore, only Proctor (Cone) will be illustrated. To change a Proctor (Cone) value, press **2** for:

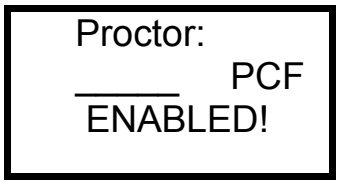


A. Recall a Stored Proctor (Cone) / Marshall Value

To enable a previously stored value, press **1**. The display is:

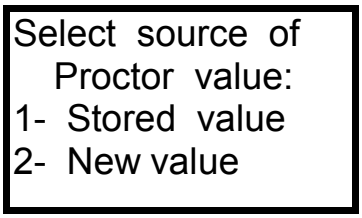


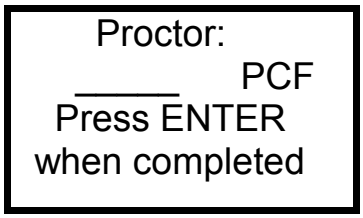
Select the desired Proctor (Cone) value by pressing **1, 2, 3** or **4** for the display:



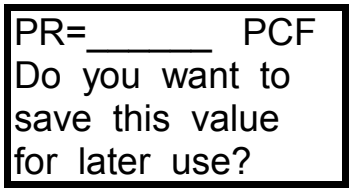
B. Enter a New Proctor (Cone)/Marshall Value

From this display press **2**. The display will be:



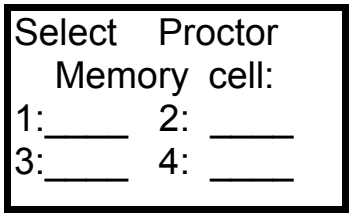


Enter the new value and press **ENTER** for the display:

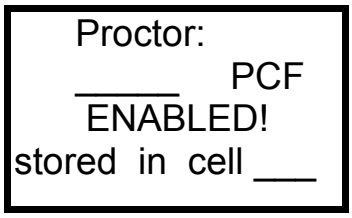


Press **YES** to save the new Proctor (Cone) value in a memory cell, for later use.

The display will be:



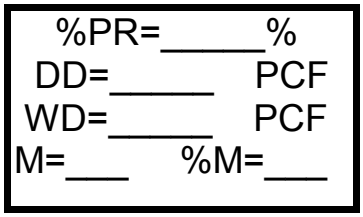
Select the desired Proctor (cone) memory cell by pressing **1, 2, 3** or **4**. The display will be:



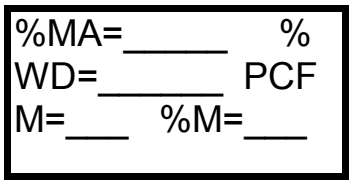
3.12 Recall Function

RECALL displays the last density and moisture readings.

Press **SHIFT** and **RECALL**. For SOIL mode, the display will be:



Press **SHIFT** and **RECALL**. For ASPHALT Mode, the display will be:



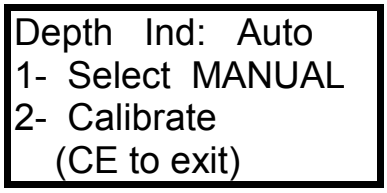
Record the percent of compaction, %PR or %MA, in column 11 on Form 582B.

3.13 Depth Function

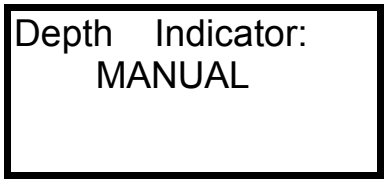
The DEPTH function allows the user to select one of two depth modes; manual or automatic. In the MANUAL mode, the gauge prompts the user to **manually** input the source rod depth using the keypad. In the AUTOMATIC mode, the gauge **automatically** reads the depth strip on the index rod and then determines the source depth. To set the DEPTH mode, press **SHIFT** and **DEPTH**.

A. MANUAL MODE

If the DEPTH mode is set to AUTOMATIC, the gauge display is:



To set the DEPTH mode to MANUAL, press **1** for:

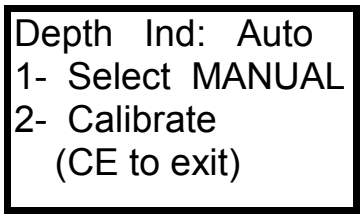


B. AUTOMATIC MODE

If the DEPTH mode is set to MANUAL, the gauge allows the user to change the mode. After changing the mode to AUTOMATIC, the gauge permits the user to calibrate the depth strip.

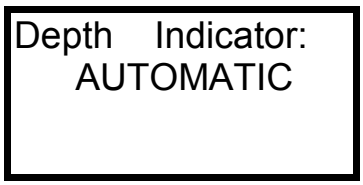
NOTE: In the AUTOMATIC depth mode, the user should calibrate the depth after extreme changes in temperature. The gauge automatically calibrates the depth when the user takes a standard count. The gauge also allows the user to calibrate the gauge as follows.

To calibrate the depth, press **SHIFT** and **DEPTH**:



Press **2**. The screen displays:

Position the source rod in the SAFE position and press **ENTER**. The gauge calibrates the depth. It then indicates that the depth indicator is in the AUTOMATIC mode as shown below, and returns to the READY display.



4. PRECAUTIONS IN PERFORMING THE DENSITY IN-PLACE (NUCLEAR) TEST

1. Keep the gauge clean.
2. Contact the Area Density Supervisor when the gauge needs servicing.
3. Transport the gauge according to US DOT regulations.
4. Do not scratch or gouge the surface of the Standard Block.
5. **Protect the gauge at all times and handle carefully**.
6. Fill holes or voids in the test surface with sand or fine material from areas near the test site.
7. Do not recharge batteries unless the battery indicator signals a low battery.
8. Be aware of safety standards when the gauge is stored or when charging the batteries.
9. If the gauge is involved in an accident, refer to the nuclear gauge book.
10. **Do not run comparison tests.**
11. Return the gauge to its case in the pickup cab when not in use.

5. CARE OF NUCLEAR GAUGE AND EQUIPMENT

After the test is completed, the gauge should be returned to the transport case in the cab of the pickup. Do not transport the gauge on the tailgate or in the box of the pickup. Experience has shown that maintenance is greatly reduced by transporting the gauge in its case in the cab of the pickup. If the gauge malfunctions, the Area Density Supervisor should be notified and any and all repairs should be made by him/her.

Due to the radioactive materials located within the nuclear density gauges, there is a potential danger when transporting and operating these gauges. The Nuclear Regulatory Commission, United States Department of Transportation, and the Michigan Department of Transportation have established safety requirements that must be conformed with. These safety requirements include, but are not limited to, the usage, storage, security, transportation of nuclear density gauges, and occupational doses and doses to members of the public. These regulations can be located within 10 CFR (energy) and 49 CFR (transportation). The safety features built into the Troxler density gauge properly shield the radioactive material, which allows an operator to use the gauge while minimizing the effects of radiation to the user.

The following steps shall be taken when the gauge is damaged ***within*** a construction project:

a. Immediately stop all construction-vehicle movement (in the immediate proximity).
b. Detain witnesses until they are interviewed.
c. Establish a fifteen (15) foot perimeter (minimum).
d. Isolate the gauge from all people.
e. Contact the Area Density Supervisor.
f. Contact MDOT's Radiation Safety Officer.
g. Complete an incident report form.
h. All of the above steps are to be conducted in the order indicated.

The following steps shall be taken when the gauge is damaged ***outside*** of a construction project:

a. Detain witnesses until they are interviewed.
b. Establish a fifteen (15) foot perimeter (minimum).
c. Isolate the gauge from all people.
d. Contact the nearest Michigan State Police Post.
e. Contact the Area Density Supervisor.
f. Contact MDOT's Radiation Safety Officer.
g. Complete an incident report form.
h. All of the above steps are to be conducted in the order indicated.

The following steps shall be taken when a gauge is lost or stolen:

a. Contact MDOT's Radiation Safety Officer.
b. Contact the Area Density Supervisor.
c. Complete an incident report form.
d. All of the above steps are to be conducted in the order indicated.

Refer to the gauge book for incident report form, telephone numbers, and radio numbers.

CALCIUM CARBIDE GAS PRESSURE METER
("SPEEDY MOISTURE TESTER")

1. DESCRIPTION

The Michigan Department of Transportation uses a calcium carbide gas pressure meter for determining moisture content. This test is used when the moisture content of the test sample has been manipulated. The current model in use is the "Speedy Moisture Tester", developed in England and in the Soils Laboratory of the Federal Highway Administration. Test apparatus shall meet the requirements of AASHTO 217. Only pressure meters sized for specimens having a mass of at least 20 grams shall be used.

The pressure meter (Figure 32) replaces the two-burner gas stove for the purpose of determining the moisture content of soils. With the pressure meter, the moisture can be determined in five minutes or less which permits obtaining density results much faster than with the stove drying method.

The principle on which the pressure meter is based is a chemical reaction which begins when the soil in the cap and calcium carbide in the body are mixed together. The moisture in the soil combines with the calcium carbide to produce acetylene gas. The gas pressure is registered on the gauge as moisture content, percent of wet weight. When testing very wet soils, an initially high reading and heat are caused by the reaction generated by the higher moisture content. Be sure that the heat has dissipated and the needle has stopped moving before the final reading.

2. CARE OF THE PRESSURE METER

The density kit contains a place designated to store and work with the equipment. It is important that the pressure meter be carried in this compartment (Figure 5). Within the pressure meter box is a place for each piece of equipment to be stored to prevent damage to the gauge, the tester, the balance beam, and also to prevent the loss of small parts such as the half sample weight (Figure 32).

The care of the pressure meter is important and is the responsibility of the Density inspector. The cap in which the soil is placed should be cleaned after each test. The body of the pressure meter should be cleaned two or three times daily.

If at any time something is wrong with the equipment, contact the Area Density Supervisor.

The cap should be cleaned after each test (Figure 33). A special cloth is provided with each kit for this purpose. This cloth should only be used to clean the cap, the scale pan, and the steel balls. The cloth should not be used for any other purpose. Do not blow into the cap as it may contain calcium carbide powder which may cause injury to your eyes.

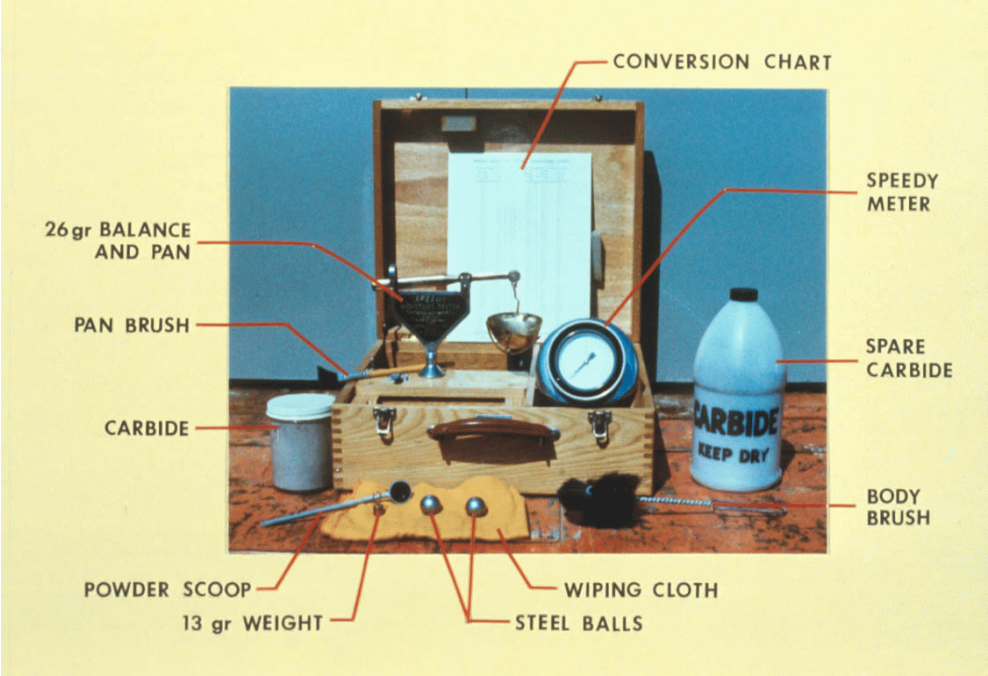


Figure 32. Calcium carbide gas pressure meter (Speedy)

Figure 33. Proper technique for cleaning the cap of the meter

When cleaning the meter body, use only the brush that comes with the kit (Figure 34). The brush provided is made of a non-conducting material that will not cause static electricity. If anything should happen to the brush, see your Area Density Supervisor for a replacement. DO NOT use a nylon brush in the meter body which could generate a static charge capable of igniting any residual acetylene gas.

Figure 34. Proper technique for cleaning the body of the meter

This is a precision instrument. While it is considered rugged for its intended use, it will not withstand abuse due to careless handling. The accuracy of test and the useful life of the pressure meter will depend on the skill and technique of the inspector and the general care taken to keep the equipment in good condition.

3. USE OF THE PRESSURE METER

The gauge reading is applied to the conversion chart supplied with each tester (Figure 35).

Note: The gauge reading is based on the wet weight of the sample. The chart converts this to dry weight.

In cold weather, run a sample through the meter to warm up the body. Disregard this reading.

The test procedure is different when testing cohesive soils than when testing granular soils.

SPEEDY MOISTURE TESTER CONVERSION CHART

Speedy Reading Wet Weight Percent	Oven-Dry Moisture Content, Percent	Speedy Reading Wet Weight Percent	Oven-Dry Moisture Content, Percent	Speedy Reading Wet Weight Percent	Oven-Dry Moisture Content, Percent
1.0	1.0	10.8	11.9	20.6	25.0
1.2	1.3	11.0	12.1	20.8	25.4
1.4	1.5	11.2	12.3	21.0	25.6
1.6	1.7	11.4	12.5	21.2	26.0
1.8	1.9	11.6	12.8	21.4	26.3
2.0	2.1	11.8	13.0	21.6	26.5
2.2	2.3	12.0	13.3	21.8	26.8
2.4	2.5	12.2	13.5	22.0	27.2
2.6	2.7	12.4	13.8	22.2	27.5
2.8	2.9	12.6	14.0	22.4	27.8
3.0	3.1	12.8	14.3	22.6	28.1
3.2	3.3	13.0	14.6	22.8	28.4
3.4	3.5	13.2	14.8	23.0	28.7
3.6	3.7	13.4	15.0	23.2	29.1
3.8	3.9	13.6	15.3	23.4	29.4
4.0	4.1	13.8	15.6	23.6	29.8
4.2	4.3	14.0	16.0	23.8	30.0
4.4	4.6	14.2	16.2	24.0	30.3
4.6	4.8	14.4	16.4	24.2	30.6
4.8	5.2	14.6	16.6	24.4	30.9
5.0	5.2	14.8	16.8	24.6	31.2
5.2	5.4	15.0	17.2	24.8	31.6
5.4	5.6	15.2	17.4	25.0	31.9
5.6	5.8	15.4	17.7	25.2	32.2
5.8	6.0	15.6	17.9	25.4	32.5
6.0	6.3	15.8	18.1	25.6	32.8
6.2	6.5	16.0	18.5	25.8	33.1
6.4	6.7	16.2	18.7	26.0	33.6
6.6	6.9	16.4	19.0	26.2	33.8
6.8	7.2	16.6	19.3	26.4	34.0
7.0	7.4	16.8	19.6	26.6	34.3
7.2	7.6	17.0	19.9	26.8	34.7
7.4	7.8	17.2	20.2	27.0	35.0
7.6	8.1	17.4	20.4	27.2	35.3
7.8	8.3	17.6	20.7	27.4	35.6
8.0	8.6	17.8	20.9	27.6	35.9
8.2	8.8	18.0	21.3	27.8	36.2
8.4	9.0	18.2	21.5	28.0	36.6
8.6	9.2	18.4	21.9	28.2	36.9
8.8	9.4	18.6	22.1	28.4	37.2
9.0	9.7	18.8	22.4	28.6	37.6
9.2	9.9	19.0	22.6	28.8	37.9
9.4	10.2	19.2	22.8	29.0	38.2
9.6	10.4	19.4	23.2	29.2	38.5
9.8	10.6	19.6	23.5	29.4	38.9
10.0	11.0	19.8	23.8	29.6	39.3
10.2	11.2	20.0	24.1	29.8	39.6
10.4	11.4	20.2	24.4	30.0	39.9
10.6	11.6	20.4	24.7		

Robert D. Miller, MDOT C&T Division
December 12, 2002
File: SPEEDY.PS

Figure 35. Calcium carbide gas pressure meter conversion chart

4. TEST PROCEDURE FOR SANDS AND GRAVELS (LOSS-BY-WASH OF 15 PERCENT OR LESS)

Place 3 scoops of calcium carbide in the body of the “Speedy” (Figure 36).

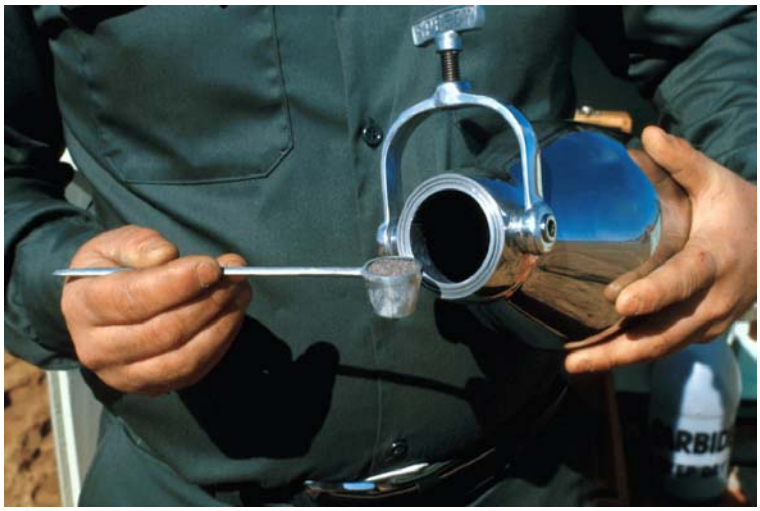


Figure 36. Place calcium carbide in body of the “Speedy”

Clean the cap in preparation for the sample (Figure 33).

Weigh the sample as quickly and as accurately as possible (Figure 37). The sample will be either 20 or 26 grams, depending on the size of the “Speedy”. Only material passing the 1/4 inch screen will be used.

Figure 37. Weigh moisture sample

Place the sample in the cap (Figure 38).

Figure 38. Place sample in the cap of meter

Hold the “Speedy” horizontally to prevent the soil and calcium carbide from mixing before the seal is made. Place the cap in position with the body, bring the stirrup around and tighten the top screw (Figure 39).

Figure 39. Fit cap and lock with stirrup and top screw

Hold the “Speedy” upright. Tap the side with your hand to get all the soil from the cap into the body (Figure 40).

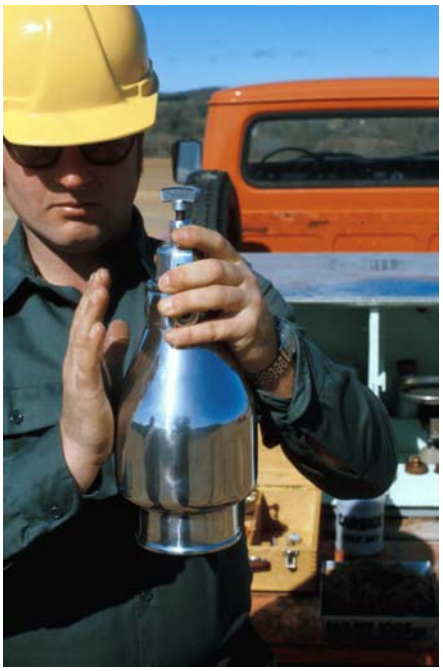


Figure 40. Hold the “Speedy” upright; tap the side of the body

Hold the “Speedy” horizontally and rotate to mix the soil with the calcium carbide (Figure 41).

Figure 41. Rotate “Speedy” horizontally

When the needle stops moving, read the result to the nearest tenth. The “Speedy” should be held horizontally when reading the dial (Figure 42).

Figure 42. Read dial with “Speedy” held horizontally

Refer the dial reading to the wet-dry conversion chart, which determines the moisture content based on dry weight. Interpolate to the nearest tenth of a percent (Figure 35). Record the moisture percent (dry weight basis) in Column B, with a circled “**S**” at the bottom of Form 582B.

While holding the “Speedy” downwind and away from your body, release the pressure slowly and empty contents (Figure 43).

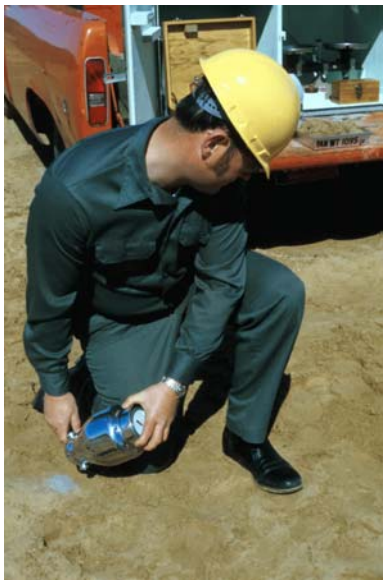


**Figure 43. Hold “Speedy” downwind and away from body.
Slowly release pressure and empty “Speedy”**

Clean the cap in preparation for the next test.

When using the pressure meter to determine the moisture content of gravels (processed aggregates), the gravel sample must be screened. Using the screen from the density kit, rub the gravel sample through the screen until all of the fines and small stones are through and just the large stones are left. Obtain the moisture sample from the material that has passed through the ¼ inch (5 mm) screen.

5. TEST PROCEDURE FOR COHESIVE SOILS (HALF SAMPLE [13 GRAM], PROPORTIONAL METHOD) (LOSS-BY-WASH GREATER THAN 15 PERCENT)

Place 3 scoops of calcium carbide in the body of the "Speedy" (Figure 36).

Hold the body of the "Speedy" horizontally. Roll in the two 1inch steel balls into the body of the "Speedy" (Figure 44). DO NOT drop the steel balls directly into the body of the "Speedy" when it is sitting upright to avoid damaging the orifice of the pressure gauge.

Figure 44. Place steel balls in body of "Speedy" with 3 scoops of calcium carbide

Clean cap with cloth provided in kit (Figure 45).

Figure 45. Cleaning the cap of the meter

Using the 1/4 inch screen from the density kit, rub the soil sample through the screen (Figure 46).

Figure 46. Using the ¼ inch (5 mm) screen from the density kit, always screen cohesive soil before obtaining the moisture sample

Attach the weight to the hook on the right end of the balance arm above the pan. Add material to the pan until the scale comes to balance (Figure 47).

Figure 47. Weigh moisture sample

Place the moisture sample in the cap of the “Speedy” (Figure 38).

While holding the “Speedy” horizontally, place the cap in position and bring the stirrup around and tighten the top screw (Figure 39).

Hold the “Speedy” upright. Tap the side with your hand to get all the soil from the cap into the body (Figure 40).

Hold the “Speedy” horizontally and rotate to put the steel balls in orbit. This mixes the soil and calcium carbide and also breaks down the sample. The mixing time required for heavy clay soils is approximately three to four minutes (Figure 41).

When the needle on the dial stops, read the results to the nearest tenth. The “Speedy” should be held horizontally when reading the dial (Figure 42).

Multiply the dial reading by **2**. Refer this result to the wet-dry conversion chart which determines the moisture content based on dry weight to the nearest tenth (Figure 35).

While holding the “Speedy” downwind and away from your body, release the pressure slowly and empty contents (Figure 43).

Inspect the cap. If the cap contains material that was not processed, the test should be repeated.

Clean the cap in preparation for the next test.

Examine the discarded moisture sample for lumps. If the sample contains clay balls that were not completely broken down, the test should be repeated and the mixing time increased.

6. PRECAUTIONS IN PERFORMING MOISTURE TESTS WITH THE CALCIUM CARBIDE GAS PRESSURE METER

1. Be sure to clean the cap before each test with the cloth furnished.

2. Always hold the “Speedy” horizontally when placing the cap to prevent the soil sample and calcium carbide from mixing before the cap is tightly sealed.

3. Be sure the needle on the meter has completely stopped moving before taking the final reading.

4. Always empty the “Speedy” by holding downwind and away from your body. The dust is an eye and respiratory irritant and can cause skin burns.

5. Do not tap the “Speedy” body with the cap when emptying the contents.

6. Use only the brush furnished in the kit to clean the pressure meter body.

7. Always screen a cohesive or gravel sample before running the moisture test.

8. Do not use the “Speedy” to determine penalty for excessive moisture.

DETERMINING MOISTURE CONTENTS OF THE SAMPLE BY THE STOVE METHOD

1. DESCRIPTION

Although the department no longer uses the stove method, it can be found in previous editions of this handbook and is considered an acceptable test method.

REPORTS AND RECORDS

1. GENERAL

The complete and final record of all density tests is made on the daily report Form 582B ("Moisture and Density Determination, Nuclear Method").

The section at the top of Form 582B should be filled in completely. If tests are run on more than one project by the same inspector, a separate sheet should be used for each project.

The inspector should begin numbering his tests each day with No. 1. The test number for each Density In-Place Test is recorded in Column 1 of Determination of In-Place Density. All failing tests are rechecked. The recheck test number will remain the same as the original test number. The recheck test number is recorded in Column 2. For all rechecks, the date of the original failing test is recorded in Column 1.

A test can fail either moisture or density or both requirements. If a test fails to meet the density requirement, the percent of compaction (Column 11) should be circled. If a test fails moisture requirements, the Moisture % (Column 8) should be circled.

The location of each In-Place Density Test should be recorded by stationing, distance right or left of centerline, and depth below plan grade. Identify the item of work (Column 16) using the abbreviations on the back of the form.

Entries on Form 582B, Determination of In-Place Density, (Columns 5, 7-11) are recorded to the nearest tenth (0.1).

Entries for Determination of Maximum Density are recorded as follows:

Columns D-F	nearest gram
Columns B, H-J	nearest tenth (0.1)
Column C	nearest ten-thousandth (0.0001)
Column G	nearest one-hundredth (0.01)

On rechecks when the Maximum Density is imported from a previous report, recopy the complete Maximum Density line from the original report. Record the date of the original test in the margin to the left of the test number.

See examples of Form 582B in section J, pages 2-5.

The distribution for Form 582B is as follows: ORIGINAL to the project file and COPIES to the Area Density Supervisor and Density Technology (Lansing).

Form 582B should be submitted daily.

FILE 301

Michigan Department of Transportation
0582B (TEST)

MOISTURE AND DENSITY DETERMINATION

NUCLEAR METHOD

DISTRIBUTION: ORIGINAL - Project Engineer, COPIES - Area Density Supervisor, Density Technology (Lansing).

*SEE REVERSE SIDE

DATE	CONTROL SECTION ID	JOB NUMBER	ROUTE NO. or STREET	GAUGE NO.
7/1/03	UR 88111	10512A	I-96 EB @ Lansing Road	90944

DENSITY INSPECTOR	CERTIFICATION NO.	PROJECT ENGINEER (MDOT)	PROJECT MANAGER	PROJECT MANAGER PHONE NO.
L.A. Brown	08765-0406	Sam Spade	Dee Smith	(312) 469-1211

DETERMINATION OF IN-PLACE DENSITY

TEST		WET DENSITY			MOISTURE			DRY DENSITY			LOCATION OF TEST				
ORIGINAL	RECHECK	COUNTS (DC)	TEST DEPTH inch	WET DENSITY PCF	COUNTS (MC)	MOIS-TURE PCF	MOIS-TURE %	DRY DENSITY PCF	MAX DENSITY PCF	PERCENT OF COM-PACTION	STATION	DISTANCE FROM ℄ FT LEFT	DISTANCE FROM ℄ FT RIGHT	DEPTH BELOW PLAN GRADE FT	ITEM OF WORK *
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
1		2371	4	137.1	93	7.5	5.8	129.6	133.7	(96.9)	12 + 75	3.0		0.5	AB
2		2254	4	141.1	98	8.3	6.3	132.8	133.7	99.3	14 + 00		3.0	0.5	AB
7/1	1	2314	4	139.1	95	7.9	6.0	131.2	133.7	98.1	12 + 75	3.0		0.5	AB
3		2082	8	119.7	54	4.2	3.6	115.5	116.0	99.6	72 + 10		4.0	6.0	B
4		2104	8	119.1	80	6.2	5.5	112.8	116.0	96.6	72 + 10	4.0		6.0	B
5		3045	6	120.3	128	10.9	10.0	109.4	112.4	97.3	21 + 10		5.0	1.0	S
6		3020	6	120.5	135	11.6	10.7	108.8	112.4	96.8	25 + 00	3.0		1.0	S
7		2303	6	133.2	212	19.0	(16.7)	114.2	119.0	96.0	62 + 50	6.0			E
7/1	7	2616	6	127.6	147	12.7	11.1	114.7	119.0	96.4	62 + 50	6.0			E

DETERMINATION OF MAXIMUM DENSITY (Soil & Bituminous)

TEST NO.	MOIS-TURE %	VOLUME MOLD CU. FT.	DENSITY DETERMINATION: WET SOIL + MOLD g	MOLD g	WET SOIL g	WET SOIL lbs.	COMPACTED SOIL WET PCF	MAX DENSITY PCF	OPTIMUM MOISTURE %
A	B	C	D	E	F	G	H	I	J
1	5.8	0.0460	4359	1462	2897	6.39	138.8	133.7	8.4
3	7.9 (S)	0.0460	4053	1462	2591	5.71	124.2	116.0	13.1
5	10.0	0.0460	4033	1462	2571	5.67	123.2	112.4	14.3
7	12.0 (S)	0.0366	4506	2320	2186	4.82	131.7	119.0	13.1

NOTE:
To convert (g) to (lbs.):
Wt. (g) ÷ 453.59 = Wt. (lbs.).
To convert (m^3) to ($ft.^3$):
Vol. (m^3) ÷ 0.02832 = Vol. ($ft.^3$).

CHART STANDARDS

DENSITY	MOISTURE
2811 / 2755	604 / 580

OPERATING STANDARDS

DENSITY	MOISTURE
2783	592

BITUMINOUS MIX DESIGN PCF

REMARKS

DENSITY INSPECTOR'S SIGNATURE	TSC/AGENCY/COMPANY
L A Brown	A.B.C. Consultants / Flint

Figure 48. Form 582B: Density Determination of Soils

FILE 301

Michigan Department of Transportation 0582B (TEST)

MOISTURE AND DENSITY DETERMINATION

NUCLEAR METHOD

DISTRIBUTION: ORIGINAL - Project Engineer, COPIES - Area Density Supervisor, Density Technology (Lansing).

*SEE REVERSE SIDE

DATE	CONTROL SECTION ID	JOB NUMBER	ROUTE NO. or STREET	GAUGE NO.
8/1/03	IR 34044	24663A	I-96 EB @ Brighton	102933

DENSITY INSPECTOR	CERTIFICATION NO.	PROJECT ENGINEER (MDOT)	PROJECT MANAGER	PROJECT MANAGER PHONE NO.
L. O. Cut	08765-0406	Sam Spade	Jim Rhodes	(411) 558-4411

DETERMINATION OF IN-PLACE DENSITY

TEST		WET DENSITY			MOISTURE			DRY DENSITY			LOCATION OF TEST				
ORIGINAL	RECHECK	COUNTS (DC)	TEST DEPTH inch	WET DENSITY PCF	COUNTS (MC)	MOISTURE PCF	MOISTURE %	DRY DENSITY PCF	MAX DENSITY PCF	PERCENT OF COMPACTION	STATION	DISTANCE FROM ℄ FT LEFT	DISTANCE FROM ℄ FT RIGHT	DEPTH BELOW PLAN GRADE FT	ITEM OF WORK *
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
1		2274	4	140.7	100		6.5		141.6	99.4	101 + 50		10.0	0.5	BAB
2		2390	4	136.3	95		6.1		141.6	96.3	140 + 40		4.0	0.5	BAB
8/1	2	2313	4	138.9	97		6.3		141.6	98.1	140 + 40		4.0	0.5	BAB
3		2420	4	135.3	78		4.5		137.8	98.2	107 + 00	8.0		0.5	BAB
4		2332	4	138.5	98		6.4		140.4	98.6	108+50	3.0		0.5	BAB

DETERMINATION OF MAXIMUM DENSITY (Soil & Bituminous)

TEST NO.	MOISTURE %	VOLUME MOLD CU. FT.	DENSITY DETERMINATION: WET SOIL + MOLD g	MOLD g	WET SOIL g	WET SOIL lbs.	COMPACTED SOIL WET PCF	MAX DENSITY PCF	OPTIMUM MOISTURE %
A	B	C	D	E	F	G	H	I	J
1	6.5	0.0365	4665	2320	2345	5.17	141.6	141.6	
3	4.5	0.0365	4602	2320	2282	5.03	137.8	137.8	
4	6.4	0.0365	4644	2320	2324	5.12	140.4	140.4	

NOTE:
To convert (g) to (lbs.): Wt. (g) ÷ 453.59 = Wt. (lbs.).
To convert (m^3) to ($ft.^3$): Vol. (m^3) ÷ 0.02832 = Vol. ($ft.^3$).

CHART STANDARDS

DENSITY	MOISTURE
3097 / 3037	561 / 539

OPERATING STANDARDS

DENSITY	MOISTURE
3067	550

BITUMINOUS MIX DESIGN PCF

REMARKS

	DENSITY INSPECTOR'S SIGNATURE	TSC/AGENCY/COMPANY
	L O Cut	Brighton TSC

Figure 49. Form 582B: Density Determination of Bituminous Aggregate Base (BAB) Mixtures

FILE 301

Michigan Department of Transportation
0582B (TEST)

MOISTURE AND DENSITY DETERMINATION

NUCLEAR METHOD

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DATE	CONTROL SECTION ID	JOB NUMBER	ROUTE NO. or STREET	GAUGE NO.
6/20/03	NH 67004	34567A	US-10 @ Evart	103822

DENSITY INSPECTOR	CERTIFICATION NO.	PROJECT ENGINEER (MDOT)	PROJECT MANAGER	PROJECT MANAGER PHONE NO.
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DETERMINATION OF IN-PLACE DENSITY

TEST		WET DENSITY			MOISTURE			DRY DENSITY			LOCATION OF TEST				
ORIGINAL	RECHECK	COUNTS (DC)	TEST DEPTH inch	WET DENSITY PCF	COUNTS (MC)	MOIS-TURE PCF	MOIS-TURE %	DRY DENSITY PCF	MAX DENSITY PCF	PERCENT OF COM-PACTION	STATION	DISTANCE FROM ℄ FT LEFT	DISTANCE FROM ℄ FT RIGHT	DEPTH BELOW PLAN GRADE FT	ITEM OF WORK *
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
1		641	BS	141.5	96		5.8		152.2	92.9	642 + 10		12.0		BT
2		615	BS	144.2	99		5.9		152.2	94.7	639 + 50		1.0		BT
3		544	BS	152.2	96		5.4		152.2	100.0	635 + 50	10.0			BT
4		624	BS	143.2	100		6.1		152.2	94.1	633 + 50		4.0		BT
5		627	BS	142.9	98		5.9		152.2	93.8	629 + 20	6.0			BT
6		583	BS	147.7	94		5.4		152.2	97.0	626 + 80		8.0		BT
								AVG.	=	95.4					

DETERMINATION OF MAXIMUM DENSITY (Soil & Bituminous)

TEST NO.	MOIS-TURE %	VOLUME MOLD CU. FT.	DENSITY DETERMINATION: WET SOIL + MOLD g	MOLD g	WET SOIL g	WET SOIL lbs.	COMPACTED SOIL WET PCF	MAX DENSITY PCF	OPTIMUM MOISTURE %
A	B	C	D	E	F	G	H	I	J
								152.2	

NOTE:
To convert (g) to (lbs.): Wt. (g) ÷ 453.59 = Wt. (lbs.).
To convert (m^3) to ($ft.^3$): Vol. (m^3) ÷ 0.02832 = Vol. ($ft.^3$).

CHART STANDARDS

DENSITY	MOISTURE
2777 / 2723	684 / 656

OPERATING STANDARDS

DENSITY	MOISTURE
2750	670

BITUMINOUS MIX DESIGN PCF

T.M.D. = 152.2

REMARKS

This is a small tonnage project. Gmm (TMD) from JMF dated 4/29/03.

DENSITY INSPECTOR'S SIGNATURE	TSC/AGENCY/COMPANY
Doug Hill	Cadillac TSC

Figure 50. Form 582B: Density Determination of Hot Mix Asphalt (bituminous) Mixtures

MDOT 0582B (TEST)

DENSITY GUIDELINES

	% DENSITY	ITEM OF WORK	DEPTH
Original Ground			
Road Embankment Areas (if specified)	90.0	OG	9"
Bridges — Within the limits as shown on the plans	95.0	OG	9"
Cut Areas			
Cuts requiring Sand Subbase	95.0	CS	9"
Cuts not requiring Sand Subbase	95.0	CN	12"
Subgrade for Bituminous Base, Aggregate Base and Concrete Widening	95.0	SG	9"
Embankments			
Regular	95.0	E	
Abutments with Piling	95.0	AP	
Abutments without Piling — Within the limits for Structure Embankment as shown on the plans	100.0	AN	
Foundation Undercut Backfill for retaining Walls, Grade Separations or Bridges	100.0	FB	
Backfill for Bridges, Culverts, Sewers, Manholes, Catch Basins, Edge Drains, and Subgrade Undercuts	95.0	B	
Subbase	95.0	S	
Subbase for Slope Paving	90.0	SP	
Aggregate Base — Concrete	95.0	SS	
Aggregate Base — Bituminous	98.0	AB	
Bituminous Aggregate Base (pulverized Bituminous used as Aggregate Base)	98.0	BAB	
Recycled Concrete Aggregate Base - used under Concrete Pavement.	95.0	CAC	
Recyceld Concrete Aggregate Base - used under Bitumious Pavement.	98.0	CAB	
Shoulders — Class I	98.0	SAA	
Shoulders — Class II and III	95.0	SA	
Bituminous Stabilization	98.0	BS	
Bituminous Paving — Base Course	97.0	BB	
Bituminous Paving — Leveling Course	97.0	BL	
Bituminous Paving — Top Course	97.0	BT	

Figure 51. Back of Form 582B Showing Density Requirements and Safety Requirements

2. PRECAUTIONS FOR RECORDS AND REPORTS

Experience has shown the following items are important to keep in mind when recording test results:

1. Send in test reports daily.
2. Report all tests, failing or passing, on Form 582B.
3. Check all calculations.
4. Circle percent of compaction and/or moisture for all failing tests.
5. All failing tests require a passing retest.
6. Use original test number and date to identify retests.
7. Use the “Remarks” space at the bottom of Form 582B to document failing tests and when corrections and retests were not completed on the same date.

APPENDIX

Definitions

Checklist for the One-Point T-99 Test

Checklist for the AASHTO T-99 Test

Checklist for the One-Point Michigan Cone Test

Checklist for the Michigan Cone Test

Checklist for the Michigan Modified T-180 Test

Checklist for the Twelve-Inch (300 mm) Layer Method Test

Checklist for Use of the Nuclear Gauge

Special Note on Weighing Procedures

Special Note on Moisture Sampling

Policy on Frequency of Testing

Equipment Furnished in Density Kits

DEFINITIONS

AASHTO — American Association of State Highway and Transportation Officials.

AGGREGATE — in highway density work this refers to gravel used as base course or shoulder material.

AGGREGATE BASE COURSE FOR HOT MIX ASPHALT (bituminous) SURFACES — the layer or layers of select material of designed thickness placed on a subbase or subgrade to support a Hot Mix Asphalt (bituminous) surface.

AGGREGATE BASE FOR CONCRETE SURFACES — the layer of select material of designed thickness placed on a subbase or subgrade to support a concrete surface.

AMERICIUM 241: BERYLLIUM — the fixed neutron source in Troxler moisture-density gauges used to determine the In-Place moisture content of the material being tested.

BACKFILL — material which replaces previously excavated material from trenches or sewers, culverts, etc.; also, fill placed in contact with retaining walls, bridge abutments, etc.

BACKSCATTER TEST — a test run with the radiation source and detectors in the same horizontal plane.

BITUMINOUS AGGREGATE BASE — pulverized pavement mixtures consisting of existing Hot Mix Asphalt (bituminous) surfaces, pulverized and mixed with some portion of the underlying aggregate base. The resulting mixture of pulverized Hot Mix Asphalt (bituminous) and aggregate base material is then compacted and used as a base course for new or recycled pavement surfaces.

CESIUM 137 — the gamma source whose radiation is used to determine the In-Place Density.

COHESIVE SOILS — fine textured soils bound together (or obtaining their strength) by an internal attraction or bond between individual grains; generally clay or clayey soils with loss-by-wash of greater than 15 percent.

COMPACTION — densification of a soil or Hot Mix Asphalt (bituminous) mixture by means of mechanical manipulation.

CONCRETE AGGREGATE BASE — pulverized pavement mixtures consisting of existing concrete surfaces, pulverized and mixed with some portion of the underlying aggregate base. The resulting mixture of pulverized concrete and aggregate base material is then compacted and used as a base course for new or recycled pavement surfaces.

CONSOLIDATION — rearrangement of soil particles to form a more dense material, resulting from either natural or mechanical action.

COUNTS/MINUTE — the amount of radiation picked up by a detector tubes and registered on digital modules or digital indicators for a one-minute period.

DEGRADATION — breakdown of soil particles beyond the natural size of individual grains, by mechanical action or natural processes.

DENSITY — weight per unit volume. See also **DRY DENSITY, WET DENSITY,** and **MAXIMUM DENSITY.**

DENSITY CONTROL — control of soil or Hot Mix Asphalt (bituminous) density during field construction to ensure that specified values are obtained, as determined by standard tests.

DIRECT TRANSMISSION TEST (Probe Test) — a method which places the source, by means of a probe, into the material to a predetermined depth.

DRY DENSITY — weight per cubic foot (meter) of dry soil.

EMBANKMENT — engineered fill, supporting a fill.

FINES — percent of soil particles finer than a No. 200 inch (75 μ) standard sieve, representing the silt and clay content.

GRANULAR MATERIAL — Michigan specification term, defined as follows:

Material Class	Sieve Analysis (MTM 109) Total Percent Passing (a)									Loss by Washing (a) (b) percent
	6" (150mm)	3" (75mm)	2" (50mm)	1" (25mm)	1/2" (12.5mm)	3/8" (9.5mm)	No.4 (4.75mm)	No.30 (.60mm)	No.100 (.150mm)	
I			100		45-85		20-85	5-30		0-5
II (c)		100		60-100					0-30 (d)	0-7 (d)
IIA (c)		100		60-100					0-35	0-10
III	100	95-100								0-15
IIIA						100			0-30	0-15

a. Test results based on dry weights
b. Use test method MTM 108 for Loss by Washing
c. Except for use in granular blankets and underdrain backfill, Class IIA granular material may be substituted for Class II granular material for projects located in the following counties: Arenac, Bay, Genesee, Gladwin, Huron, Lapeer, Macomb, Midland, Monroe, Oakland, Saginaw, Sanilac, Shiawassee, St. Clair, Tuscola, and Wayne counties.
d. Grading requirements are 0-20 for the No. 100 sieve and 0-5 for loss by washing when material is used as backfill for underdrains.

GRANULAR SOILS — coarse-grained soils with loss-by-wash of 15 percent or less. Granular materials have no cohesion, and derive their strength from internal stability.

GRAVEL— rounded or angular particles of rock which will pass a 3 inch (75 mm) sieve and be retained on a No, 10 (2 mm) sieve (AASHTO).

"Coarse": passing the 3 inch (75 mm sieve) and retained on the 1 inch (25 mm) sieve.

"Medium": passing the 1 inch (25 mm) sieve and retained on the ⅜ inch (9.5 mm) sieve.

"Fine": passing the ⅜ inch (9.5 mm) sieve and retained on the No. 10 (2 mm) sieve.

HOT MIX ASPHALT (BITUMINOUS) AGGREGATE BASE — a pulverized Hot Mix Asphalt (bituminous) material mixed with the underlying aggregate base, compacted and used as a base for Hot Mix Asphalt (bituminous) surface.

HOT MIX ASPHALT (BITUMINOUS) MIXTURES — Hot Mix Asphalt (bituminous) mixtures used as bases, binders, leveling and top courses.

LOSS-BY-WASH — an estimate of the percentage of soil fines (P-200). That fraction of the soil sample that is subject to suspension in water and can be decanted from the balance of the sample hydraulically.

MAXIMUM DENSITY — Dry Density (unit weight) of a material obtained by a specified amount of compaction at the existing moisture content.

MOISTURE CONTENT — the quantity of moisture in a soil expressed as a percentage of the soil's dry weight. See also **OPTIMUM MOISTURE** and **MOISTURE, PCF (kg/m^3)**.

MOISTURE-DENSITY CURVE — the curve showing the relationship between "dry unit weight" (density) and "moisture content" (water content) of a soil for a given compactive effort. The Maximum Density (Maximum-Unit-Weight) and Optimum Moisture are obtained from the curve.

MOISTURE, PCF (kg/m^3) — the amount of moisture determined using the nuclear gauge expressed in pounds per cubic foot (kilograms per cubic meter).

OPTIMUM MOISTURE — moisture content in a soil at which a specified amount of compaction will produce the Maximum Dry Density.

PERCENT COMPACTION — the ratio, expressed as a percentage of the In-Place unit weight of a soil to the Maximum-Unit-Weight obtained in a laboratory or field compaction test.

PROBE — the rod which contains the radioactive source which is inserted into the material to be tested.

PULVERIZED HOT MIX ASPHALT (BITUMINOUS) — see Bituminous Aggregate Base.

ROADBED — the portion of the roadway between the outside edges of finished shoulders, or the outside edges of berms, back of curbs, or gutters, when constructed.

SATURATION — the moisture content at which all voids in soil mass are filled with water.

SCALER — the electronic module in the nuclear gauge which records and displays the Counts/Minute (test reading) when running standards or tests.

SETTLEMENT — decrease in elevation of the surface of an embankment due to consolidation of soil within the embankment, generally resulting from its own weight, over a period of time following construction.

SOIL — unconsolidated mineral matter at or near the earth's surface.

SOURCE — the radioactive material sealed in the gauge.

STABILIZATION — a recycling method used to improve the stability and bearing capacity of a Hot Mix Asphalt (bituminous) material by admixing hot bitumen In-Place and recompacting.

STANDARD BLOCK — a polyethylene block which is used daily to field calibrate (standardize) the nuclear gauge.

STANDARD COUNT — the Counts/Minute run and recorded daily on the Standard Block. The Standard Count is sometimes referred to as the Operating Standard.

SUBASE — the layer of granular material placed on the subgrade as a part of the pavement structure.

SUBGRADE — the portion of the earth grade upon which the pavement structure is placed.

TEMPLATE (SCRAPPER PLATE) — a metal plate used to prepare the test site. It is used to guide the drill rod in preparing a hole for the source rod for direct transmission measurements.

TEST COUNTS — the amount of radiation detected by the gauge for a moisture or density test.

VOIDS — spaces between individual soil particles occupied by air and/or water.

WET DENSITY — the total weight of a unit volume of material. Includes the weight of solids plus the weight of water.

WET MAXIMUM DENSITY — Wet Density (unit weight) of a material obtained by a specified amount of compaction at the existing moisture content.

Checklist for the One-Point T-99 Test	
1.	Obtain sample (approximately 3500 grams).
2.	Break up the sample by working it through the screen.
3.	Check moisture content, which should be within a range from optimum to 4 percent below optimum at the start of the test.
4.	Assemble the Proctor mold.
5.	Place the mold on the pounding block.
6.	Place a layer of soil in the mold (enough to fill the mold one-third full after compaction).
7.	Compact this first layer by 25 evenly distributed rammer blows.
8.	Place a second layer of soil in the mold (enough to fill it two-thirds full after compaction).
9.	Compact the second layer by 25 evenly distributed rammer blows.
10.	Place a third layer of soil in the mold (enough so that after compaction, it will extend from ¼ to ½ inch (5 to 15 mm) above the top of the mold.
11.	Compact this third layer by 25 evenly distributed rammer blows.
12.	Remove the collar.
13.	Use the strike-off bar to trim the sample even with the top of the mold.
14.	Remove the base plate.
15.	Weigh the mold and sample.
16.	Remove the soil from the mold.
17.	Obtain a moisture sample from the center of the soil sample. (Required when the moisture content has been manipulated).
18.	Determine Moisture % and Compacted Soil Wet, PCF .
19.	Use the On-Point T-99 Chart to determine Maximum Density and Optimum Moisture.
20.	Record the test results on Form 582B.

Checklist for the AASHTO T-99 Test	
1.	Obtain sample (approximately 5000 grams).
2.	Break up the sample by working it through the screen.
3.	Check moisture content, which should be approximately 4 percent below optimum at the start of the test.
4.	Assemble the Proctor mold.
5.	Place the mold on the pounding block.
6.	Place a layer of soil in the mold (enough to fill the mold one-third full after compaction).
7.	Compact this first layer by 25 evenly distributed rammer blows.
8.	Place a second layer of soil in the mold (enough to fill it two-thirds full after compaction).
9.	Compact this second layer by 25 evenly distributed rammer blows.
10.	Place a third layer of soil in the mold (enough so that after compaction it will extend from ¼ to ½ inch (5 to 15 mm) above the top of the mold.
11.	Compact this third layer by 25 evenly distributed rammer blows.
12.	Remove the collar.
13.	Use the strike-off bar to trim the sample even with the top of the mold.
14.	Remove the base plate.
15.	Weigh the mold and sample.
16.	Remove the soil from the mold.
17.	Obtain a moisture sample from the center of the soil sample.
18.	Determine the Moisture %.
19.	Compute dry density (compacted soil dry, Form 582B)
20.	Thoroughly break-up the remaining portion of the molded specimen by working it through the screen.
21.	Recombine with the original sample and mix thoroughly.
22.	Add approximately 2 percent moisture and mix thoroughly.
23.	Reassemble the mold and repeat steps 5 through 22. This process will need to be repeated at least three times.

Checklist for the AASHTO T-99 Test	
24.	Plot moisture content versus dry density for each data set.
25.	Connect the graph points for all tests with a smooth parabolic curve.
26.	Determine the Maximum Density, PCF and Optimum Moisture content.

Checklist for the One-Point Michigan Cone Test	
1.	Obtain sample (approximately 3500 grams).
2.	Sample must have a moisture content between 5 percent and optimum.
3.	Place enough soil in the cone to fill it one-third full after compaction.
4.	Pound the cone 25 times or more on the pounding block, striking it sharply.
5.	Place enough soil in the cone to fill it two-thirds full after compaction.
6.	Pound the cone 25 times or more.
7.	Fill the cone completely with soil.
8.	Pound the cone 25 times or more.
9.	Completely fill the cone with soil.
10.	Pound the cone at least 10 times.
11.	Repeat steps 9 and 10 until no more consolidation occurs.
12.	Level off the material at the top of the cone with the stopper or straight-edge.
13.	Weigh the cone and sample.
14.	Empty the cone on the bock or in a pan by striking the cone on the open end.
15.	Obtain moisture sample from the center of the cone. (Required when the moisture content has been manipulated).
16.	Determine sample moisture content and Compacted Soil Wet, PCF.
17.	Use the One-Point Cone Chart to determine Maximum Density and Optimum moisture.
18.	Record the results on Form 582B.

Checklist for the Michigan Cone Test	
1.	Obtain sample (approximately 3500 grams).
2.	Sample moisture content should be within a range of 5 percent to just short of saturation. Pound a series of cones at different moisture contents within this range to determine the Maximum Density. The Maximum Density is the highest value obtained in this series.
3.	Place enough soil in the cone to fill it one-third full after compaction.
4.	Pound the cone 25 times or more on the pounding block, striking it sharply.
5.	Place enough soil in the cone to fill it two-thirds full after compaction.
6.	Pound the cone 25 times or more.
7.	Fill the cone completely with soil.
8.	Pound the cone 25 times or more.
9.	Completely fill the cone with soil.
10.	Pound the cone at least 10 times.
11.	Repeat steps 9 and 10 until no more consolidation occurs.
12.	Level off the material at the top of the cone with the stopper or straight-edge.
13.	Weigh the cone and sample.
14.	Empty the cone on the block or in a pan by striking the cone on the open end.
15.	Obtain a moisture sample from the center of the cone.
16.	Determine the moisture content.
17.	Compute the Maximum Density.
18.	Three tests should be made within the moisture range as explained in step 2. The highest test result is the Maximum Density, PCF.
19.	When water is added be sure and mix the sample thoroughly.
20.	Record the test results on Form 582B.

Checklist for the Michigan Modified T-180 Test	
1.	Perform the In-Place tests in the “Asphalt Mode”.
2.	Obtain the Maximum Density sample from the In-Place test location.
3.	The mold is pounded at existing In-Place moisture.
4.	Make sure the Proctor mold is assembled correctly.
5.	The pounding block should be placed on a firm ground or pavement.
6.	Place a layer of material in the mold (enough to fill the mold one-fifth after compaction).
7.	Compact the layer with 25 evenly distributed blows using the 10 pound (4.5 kg) rammer.
8.	Place the second, third and fourth layers in the mold, each layer filling one-fifth of the volume of the mold, and compact each layer with 25 evenly distributed blows.
9.	Place the fifth layer in the mold. Enough material is used so that after compaction, the material will extend from ¼ to ½ inch (5 to 15 mm) above the top of the mold).
10.	Compact the fifth layer with 25 evenly distributed blows.
11.	Remove the collar.
12.	Use the strike-off bar to trim the excess material even with the top of the mold.
13.	Remove the bottom plate from the mold.
14.	Weigh the sample and mold to the nearest 5 grams.
15.	Complete the computations through Column 8 (Compacted Soil Wet, PCF) (kg/m^3) on Form 582B.
16.	The resultant value from Column 8 is the Maximum Density, (wet) and should also be recorded in Column 9 (Maximum Density, PCF).
17.	This test is normally used on In-Place recycling jobs. The material changes frequently for this type of work, and therefore, the Maximum Density will have to be re-established more often and also when the moisture changes more than 1.5 percent.

Checklist for the Twelve-Inch (300 mm) Layer Method Test	
1.	Obtain the Maximum Density from the In-Place test location.
2.	The Loss-By-Wash determines the test method used to establish Maximum Density.
3.	The mold is pounded at existing field moisture.
4.	Do not use the One-Point Chart to establish Maximum Density.
5.	If the Loss-By-Wash is greater than 15 percent, work the sample through the screen before pounding the mold. Pound the mold in three equal layers using 25 blows per layer.
6.	If the Loss-By-Wash is 15 percent or less, use the cone to establish the Maximum Density.
7.	Weigh the completed mold to the nearest 5 grams.
8.	Using the moisture content obtained from the In-Place test, compute the Maximum Density. Maximum Density, dry weight basis, is obtained using this formula: $\frac{\text{Compacted Soil Wet} \times 100}{\text{Moisture \%} + 100}$

Checklist for Use of the Nuclear Gauge Troxler Model 3440	
1.	Check the ID number on the gauge book and the standard block and be sure they match the ID number on the gauge. Gauge books and standard blocks are not interchangeable.
2.	Turn the gauge on and allow a 20 minute warm-up before running standards.
3.	Record Chart Standards for Density and Moisture.
4.	Run Operating Density and Moisture Standards and record.
5.	Select the test location and prepare the test site.
6.	Run the Density and Moisture tests and record the test readings.
7.	Record the Wet Density, PCF (kg/m^3) and Moisture, PCF (kg/m^3).
8.	Record the Dry Density, PCF (kg/m^3) and Moisture, %.
9.	Record the Density and Moisture Counts.
9.	Record and program the gauge with the correct Maximum Density, PCF (kg/m^3).
10.	Record the Percent of Compaction.
11.	When through running a test, lock and return the gauge to the transport case in the pickup cab.
12.	Rechargeable batteries have a memory and repeated needless charging will shorten the battery life. Do not recharge batteries unless **<Batteries Low!>** is visible on the display. For a full charge, re-charge the gauge for 16 hours. A full charge should last from four to six weeks.
13.	Report malfunctions promptly to the Area Density Supervisor.
14.	Gauge users are not authorized to make field repairs or perform gauge maintenance. Only Density Supervisors are permitted to maintain or repair gauges.
15.	Follow all safety rules and regulations.
16.	Transport the gauge according to US DOT regulations.
17.	When the gauge is left unattended in a vehicle, both the vehicle and the gauge must be locked.

Special Notes on Weighing Procedures	
1.	Check the weights of cones and molds periodically.
2.	A balance or scale conforming to AASHTO M231, Class G20 shall be used for weighing Proctor molds or cones.
3.	Use the balance or scale furnished with the “Speedy” kit for weighing moisture samples.

POLICY ON MINIMUM FREQUENCY OF TESTING

For density control of embankments, subbase, selected subbases, base courses, and Hot Mix Asphalt (bituminous) surfaces, a sufficient number of tests should be made to ensure that the specified results are being obtained. The frequency of testing will vary with the project, the placing operation, and the material being used. For a job on which compaction is relatively easy to obtain, the material is reasonably uniform, and the compacting methods are consistent, a minimum of tests are needed for control. The minimum frequency of tests needed under these relatively ideal conditions follow. Most tests will require more tests for proper control.

Specification/Material	Test Guide	Frequency
205.03H Embankment	Density	1 test per 1000 cyds (750 m^3) of material
(Specifications require each material to meet the required density and moisture content.)		
301 Subbase	Density	1 test per 500 ft (150 m) per width of 24 ft (7.2 m) or less
(Specifications require each material to meet the required density and moisture content.)		
206.04B Structure Backfill	Density	1 test per 300 cyds (230 m^3) of material
(Specifications require each material to meet the required density and moisture content.)		
302 Aggregate Base Courses	Density	1 test per 500 ft (150 m) per width of 24 ft (7.2 m) or less
(Specifications require each material to meet the required density and moisture content.)		
504 Hot Mix Asphalt (bituminous) Mixtures	Density	1 test per 1000 ft (300 m) per width of 24 ft (7.2 m) or less
(Specifications require each material to meet the required density and moisture content.)		

It must be emphasized that project conditions normally require more frequent testing for proper control. In addition, the specifications require that each layer must meet compaction requirements before the succeeding layer is placed.

EQUIPMENT FURNISHED IN DENSITY TEST KITS

2 - 2000 gram weights and one (1) box of 1 to 1000 gram weights

1 - Balance or Electronic Scale

1 - T-99 rammer

1 - T-180 rammer

1 - Proctor mold

1 - Strike-off bar

1 - Michigan Cone with stopper

2 - 10 inch by 10 inch (250 mm by 250 mm) pans

1 - Large 12 inch (300 mm) spoon

1 - One-Point Cone Chart

1 - One-Point T-99 Chart

1 - ½ Gallon (2 Liter) plastic water bottle

1 - ½ Gallon (2 Liter) plastic carbide jug

1 - “Speedy” Moisture Tester Kit

1 - 4 inch (100 mm) spatula

1 - Density Handbook

1 - 8 inch by 8 inch by 10 inch (200 mm by 200 mm by 250 mm) wood pounding block

1 - 18 inch by 18 inch (450 mm by 450 mm) screen with ¼ inch (6 mm) mesh

1 - Nuclear gauge and support equipment